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A FACTOR-ANALYTIC STUDY OF FLEXIBILITY IN THINKING

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THIS is a condensed report of the eighth major study in a series designed to explore abilities considered to be important in the successful performance of high-level personnel.[3] Earlier studies had dealt with somewhat broad areas designated as reasoning (5, 10), creative thinking (23), evaluation (14), and planning (1). One study cut across three of these areas (11). Another was limited to the investigation of fluency of thinking (8). The study being reported is aimed specifically at the limited subject of flexibility of thinking, with the general objective of inquiring intensively into its properties.

One of the major objectives of the study was to relate the factors of flexibility of thinking to such traditional concepts as rigidity, perseveration, persistence, gestaltbindung, and functional fixedness. An incidental objective was to determine possible relationships of a modified Luchins Water Jar test (17) to factors of flexibility of thinking. The Luchins test has been widely utilized as a measure of rigidity without sufficient evidence that it measures a trait of this kind.

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[3] Under contract N6onr-23810 with the Office of Naval Research. The ideas expressed in this paper are our own and do not necessarily represent the opinions of the Office of Naval Research. Reproduction in whole or in part is permitted for any purpose of the United States Government. Guilford is responsible investigator and director of the project, Christensen was assistant director at the time of this study, and Frick was in direct charge of the study. Dr. Norman W. Kettner assisted in the early stages and Mr. Philip R. Merrifield at most stages of the investigation.

Some Background of the Study

The hypothesis that there is a broad disposition of rigidity in human personality has been commonly overgeneralized. It is apparently often believed that if a person shows rigidity of behavior in one area of functioning he will be likely to show it in many others, including sensory or perceptual activities, psychomotor activities, thinking, and even in his attitudes, such as attitudes involved in the concept of the ethnocentric or fascist disposition (19). Such a hypothesis would call for substantial correlations among various kinds of indices of rigidity vs. flexibility in all the areas of behavior indicated.

From an excellent review that mentions the more recent work on rigidity, by Taylor and McNemar (21), one can hardly fail to obtain the impression that (a) there is no unitary, general trait of rigidity that applies to all kinds of operations—sensory, perceptual, thinking, psychomotor, and attitudinal; and (b) there is much evidence of a number of much more limited unitary traits of rigidity (or of flexibility).

Some of the limited factors of rigidity or flexibility may be mentioned. Thurstone (22) reported a factor that he described as flexibility in dealing with perceptual organizations, or a freedom from gestaltbindung. It was characteristic of behavior in tests with hidden faces or hidden geometric figures. In several studies there has been found what appears to be a rigidity factor common to certain psychomotor tests, including studies by Cattell and Tiner (2), Oliver and Ferguson (18), and Scheier and Ferguson (20).

In the area of thinking, the strongest evidence of flexibility factors comes from previous studies in this series from the Aptitudes Project. In the first study of creative-thinking abilities, two distinct flexibility factors were found (23). They were designated as *spontaneous flexibility* and *adaptive flexibility*. Definitions of these factors will be given in the next section, where hypotheses concerning them will be discussed. They have been found a number of times in subsequent studies (1, 11, 12).

We cannot take for granted the assumption that our two flexibility factors are opposite to rigidity and hence bear upon the question of one vs. several rigidity factors. In the hypotheses that follow, however, we consider the possibility that two different varieties or rigidity—perseveration and persistence—are opposite to our two flexibility factors. Our study was designed to obtain the answer to the question of whether these two kinds of rigidity of thinking are bipolar with our two kinds of flexibility.

We shall not be able to present evidence that our two factors of flexibility are distinct from the psychomotor-rigidity factor that has been reported. We can say, however, that they are demonstrated by quite different kinds of tests and we should be willing to predict that they are distinct from psychomotor flexibility. We have a little evidence to report concerning the distinctness of Thurstone's perceptual-flexibility factor from our thinking-flexibility factors. We have no evidence concerning the possible relation of our factors to rigidity of attitudes.

Hypotheses

Since the main emphasis in the hypotheses concerning the factors of flexibility of thinking have to do with the question of whether two forms of rigidity—perseveration and persistence—are qualities directly psychologically opposite to *spontaneous flexibility* and *adaptive flexibility,* respectively, it is important first for us to define those concepts.

Definitions.

Spontaneous flexibility: The ability to produce a diversity of ideas in a relatively unstructured situation.

Perseveration: The tendency of behavior once operating to run its course until exhaustion or until disruption by some intruding influence.

Adaptive flexibility: The ability to change set in order to meet requirements imposed by changing problems.

Persistence: The insistence, with continuing motivation, upon pursuing one line of approach to a problem in the face of altered conditions.

It may be noted that the distinction we have made between what may be regarded as two forms of rigidity conforms very closely to the distinction that Cattell and Tiner (2) made in terms of "process" and "structure." The one is a passive state of inertia; the other an active urge to repeat responses.

General Hypotheses. In view of the four definitions just given, and with several tests in the battery to represent each concept, we might expect one of three simple, alternative outcomes:

1. Two factors will be found in the area of flexibility of thinking—*spontaneous flexibility* and *adaptive flexibility,* as before—with none of the tests designed to measure perseveration or persistence significantly related to them or defining factors of their own.
2. Two bipolar factors will be found, with tests of perseveration going generally with those for *spontaneous flexibility* and tests of persistence going with *adaptive flexibility.*
3. Four factors will be found, with factors of perseveration and persistence separate and distinct from the two flexibility factors and from one another.

There are, of course, several other possibilities, combining features of the three cases just described. A possibility that was regarded as very remote was the emergence of one flexibility-rigidity factor. The outcome most expected was alternative 2.

Specific Hypotheses. In the discussion of hypotheses, we shall take up each possible factor that might emerge from the factor analysis in turn. Concerning it we shall offer different alternative subhypotheses concerning the properties of the factor. It is from such subhypotheses that we select, adapt, or develop tests to be used in the battery for analysis.

Hypotheses concerning factors of flexibility and rigidity will be mentioned first, and at some length, since they are of crucial interest in this study. A general comment is in order concerning the scoring of tests of perseveration and persistence. In scoring such tests we have the alternative of assigning high numbers to indicate much of either quality or the alternative of reversing the scales so that high scores mean freedom from those qualities. We have chosen the latter alternative. If our prediction of bipolar factors is supported, we should then find positive correlations between tests of flexibility on the one hand and tests of rigidity, thus scored, on the other and a positive manifold in the factorial solution.

I. *Spontaneous flexibility*

a. The ability to shift mental set freely, making it possible to get away from more obvious and more trite responses.

Tests: Riddles (clever)*,[4] Rhyming Definitions*, Consequences (remote), and Unusual Uses. Unlike the tests in the next group (for subhypothesis Ib), the first two tests in this group require essentially one right answer. The answer is a most unusual idea, however, and the examinee may have to reject a number of more obvious or trite ideas in arriving at it. The last two tests were used primarily as reference tests, having previously shown relations to the factor. They both fit logically this subhypothesis.

b. The ability to react to a relatively unstructured situation in divergent channels or directions.
Tests: Impossibilities, Twenty Questions*. The first test permits considerable freedom on the part of the examinee. If he is to compile a long list, he must respond in many, quite-different directions. Although the test had previously shown relations to the factors of *ideational fluency* and *originality*, it was believed that it had possibilities of measuring flexibility in view of this subhypothesis. The test Twenty Questions calls for a variety of ideas in order to cover the requirements of the task. Considerable searching for ideas must occur. A unique feature of this test in this context, however, is that there must be interrelations among the questions.

I′. *Perseveration*

a. Inertia in thinking; a tendency to let a set run its course.
Tests: Brick Uses (flexibility), Object Naming*. The flexibility score of the Brick Uses test is the number of times the examinee changes category of response, regardless of the number of single responses. The Object Naming test was designed according to the same principle. The examinee is told to list names of objects. Will he tend to resort to "clustering," that is, giving runs of objects from some category, or will he change categories frequently?

The test Brick Uses (flexibility) has often been used as a marker for the factor of *spontaneous flexibility*. There is no implication in placing a known spontaneous-flexibility test under the hypothesis of a factor of perseveration that the battery is thus "loaded" in favor of one factor. It might turn out that we should consider our factor of *spontaneous flexibility* as perseveration and that other kinds of tests define the flexibility factor.

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[4] An asterisk indicates a new test constructed or adapted for this study.

b. A tendency toward elaboration of themes rather than changes of theme.

Tests: Chain Associations*, Syllables*. In Chain Associations the examinee is told to list words, each one associated in some way with the word preceding. In Syllables he is told to produce two-syllable, nonsense words. These two tests, as compared with the two under hypothesis I′a, were thought to involve a more planful, though not necessarily intentional, adoption of a method or theme that runs its course. The distinction is admittedly not very great. In Chain Associations the examinee can give runs of closely associated words. In Syllables he can vary his responses by only slight amounts, making runs of similar spelling, or he can avoid this.

II. *Adaptive flexibility*

a. The ability to restructure problems.

Tests: Insight Problems*, Puzzles*, Planning Air Maneuvers. The first two tests include some problems that seem easy enough to understand as one reads them, but actually it is difficult to arrive at the interpretation or the key idea which makes the solution possible. More obvious, possible structures have to be replaced by less familiar ones. Interpretations must be reached that are out of the ordinary. One reason for including such tests was to determine whether the factor of *adaptive flexibility* previously found would be of importance in problem solving of a more common type than that afforded by the test Match Problems. It was also recognized that previous tests of this factor had inadvertently avoided conceptual material. Would tests of a verbal, conceptual type also be related to the same factor, or would they perhaps define a flexibility factor of their own?

Planning Air Maneuvers had been found related to the factor in the study of planning (1). In this test the examinee who can do the skywriting of two consecutive capital letters in a variety of ways has a better chance of finding the most efficient way, which the instructions call for.

b. The ability to solve problems in several ways.

Tests: Match Problems II, Squares*. A test called Match

Problems was one of the first to bring out the factor of *adaptive flexibility* (23). It calls for rather unusual and surprising answers to some of the problems, but only one answer to each problem. Match Problems II presents problems, each of which has several correct solutions. The examinee must be able to change his method of solution in every problem in order to make a good score. The Squares test was constructed on the basis of the same principle.

c. The ability to drop associative connections just used and to adapt to new ones.

Tests: Circle Square II, Circle Square Triangle. The same figures—as named in the test titles—must be associated with the names of different common objects, and with different positions, in each item. Keeping up with the changing associative connections, free from confusions, seems to be the important aspect of these tests. The second test is more complicated than the first. Circle Square II had not been found related to *adaptive flexibility* in the creativity analysis (23) but was found related to a flexibility factor of some kind by Dingman (3). One reason for including Circle Square II was to attempt to decide between these two conflicting results. Circle Square Triangle was included because of its similarity to Circle Square II and because, being more complicated, it was thought to have a better chance of relationship to flexibility. It should offer more opportunities for conflicting associations.

II′. *Persistence*

a. The continued maladaptive use of a learned procedure.

Test: Water Jars*. This test is a group-form adaptation of the Luchins test. One purpose for including it was to determine whether the rigidity that it has been assumed to measure has something in common with our tests of *adaptive flexibility.* In our own chosen terminology, it seems to fit under the category of persistence. If a single flexibility-persistence factor is found, would the Luchins test be a good measure of it? In placing the Water Jars test in the category of "continued maladaptive use of a learned procedure" we have adopted a hypothesis similar to that of Ferguson, who attributes rigidity in general to habit interference or negative transfer effects (18, 20).

Another interest was to learn what we could regarding the factorial composition of a test that has been in such common use in experimental research, without information as to what it actually measures. We rather expected that the major loadings would be on reasoning factors, probably *general reasoning* and *logical evaluation* (since the type of problem involved bears some resemblance to ordinary arithmetic-reasoning problems) with perhaps some loading on *adaptive flexibility,* depending upon how much the persistence of learned procedure operates in some examinees. A detailed report on an experimental study that throws additional light on the Water Jar test has been published in another place (4).

b. The continued operation of habitual meanings.

Tests: Sign Changes, Object Synthesis. The Sign Changes test requires the examinee to ignore the printed algebraic signs he sees in simple numerical-operation equations and by instruction to operate with substituted signs that he has to keep in mind. The instructions change frequently. The Object Synthesis test requires the examinee to tell what new objects he would make out of pairs of given objects. He must put aside the common meaning and use of each object in giving it a new meaning and use in the new combination.

c. Resistance to restructuring.

Tests: Camouflaged Words*, Hidden Figures, Penetration of Camouflage, Figure Analysis. In Camouflaged Words, a meaningful sentence must be broken down at some point to regroup consecutive letters to build the name of a sport or game. The other three tests present visual figural material that is ambiguous. The first contains hidden Gottschaldt figures. The second contains hidden faces, several in the same scene. The third contains outline drawings of simple, meaningful objects, all concealed in a larger meaningful object. The examinee is told what kinds of things to look for in the three tests. How well can he shake off the more obvious configuration, emphasized by the more inclusive picture, in order to use parts of it in seeing the new objects? The three figural tests were of considerable interest in this study for they provided a possible basis for the segregation of a figural-adaptive-flexibility factor. The Camouflaged Words test, however, is composed of what has become recognized as "structural" material and hence it might

TABLE 1

Summary of Information Regarding Tests

Test	Task required	Format*	Reliability**
1. Brick Uses (flexibility)	List uses in varied categories	C	.67[a]
2. Brick Uses (fluency)	List particular uses in quantity	C	.66[a]
3. Camouflaged Words	Find name of sport or game hidden in sentence	C	.65
4. Chain Associations	In giving free, chain associations, vary clusters or categories	C	.76
5. Circle Square II	Change objects associated with circle and square	MC	.83[b]
6. Circle Square Triangle	Change objects associated with three forms	MC	.75
7. Consequences (low quality)	List consequences to hypothetical event in quantity	C	.70
8. Consequences (remote)	List remotely connected consequences to an event	C	.69
9. Figure Analysis	Identify familiar outline objects concealed in larger object	C	.60
10. Hidden Figures	Identify one of five Gottschaldt figures in larger figure	MC	.82
11. Impossibilities	List impossible events in quantity	C	.40[a]
12. Insight Problems[d]	Solve problems calling for very unusual interpretations	C	.59[c]
13. Logical Reasoning	Select logically correct conclusion to given premises	MC	.80[b]
14. Match Problems II	Remove number of matches to leave a number of squares in several ways	C	.65
15. Object Naming	List objects of a specified class, giving responses in varied subclasses	C	.47
16. Object Synthesis	Make a new object by combining two other common objects	C	.61
17. Penetration of camouflage[e]	Find hidden faces in a scene	MC	.76
18. Planning Air Maneuvers[e]	Plan skywriting of two letters in sequence	MC	.46
19. Plot Titles (clever)	Write clever-rated titles for a story plot	C	.79
20. Plot Titles (low quality)	Write titles for a story plot in quantity	C	.91

* C stands for completion forms and MC for multiple choice forms.

** Estimated by alternate-forms method, with Spearman-Brown correction, unless otherwise indicated.

[a] Communalities used as lower-bound estimates

[b] Estimates from previous studies

[c] By Kuder-Richardson Formula 21

[d] Adapted by permission from a test by R. S. Crutchfield

[e] Adapted by permission from an Air Force test

TABLE 1—*continued*
Summary of Information Regarding Tests

Test	Task Required	Format*	Reliability**
21. Puzzles	Solve problems requiring careful evaluation	C	.44[c]
22. Rhyming Definitions	Produce two-word rhyming definitions of objects	C	.77
23. Riddles (clever)	Explain riddles in clever manner	C	.52
24. Riddles (obvious)	Give commonplace interpretations of riddles	C	.51
25. Ship Destination	Find distance between two letters on a matrix under varying conditions	MC	.87[b]
26. Sign Changes	Solve numerical operations using revised sign systems	C	.78
27. Squares	Place X's in checkerboard squares, with several solutions to same problem	C	.38
28. Syllables	Form two-syllable, nonsense words in varied categories	C	.89
29. Twenty Questions	Write all the questions (for yes-no answers) needed to identify an object	C	.54
30. Unusual Uses	List several unusual uses for each common object	C	.68
31. Verbal Comprehension	A vocabulary test	MC	.82[b]
32. Water Jars	A group form adapted from Luchins' test	C	.63[a]

go with Match Problems, unless a separate persistence factor were found.

Reference Factors and Their Tests. Owing to the probable factorial complexity of many of the tests mentioned above, certain other, nonflexibility factors were expected to emerge. For this reason marker tests for these factors were included in the battery. The factors and their tests are:

Verbal comprehension: Verbal Comprehension
General reasoning: Ship Destination
Logical evaluation: Logical Reasoning
Originality: Consequences (remote); Plot Titles (clever)
Ideational fluency: Consequences (low quality); Plot Titles (low quality); Brick Uses (fluency)

The Test Battery

In accordance with the hypotheses, 28 tests were selected for inclusion in the battery. Four tests provided two scores each, hence there were altogether 32 experimental variables derived from the battery. The 11 newly-constructed tests had been pretested and studied statistically, using samples of from 50 to 100 university students.[5] Table 1 presents a list of the 32 test variables in alphabetical order, with a minimum of description, including estimates of reliability.

Procedures

Testing and Treatment of Scores. The test battery was administered to 208 Air Cadets at Lackland Air Force Base early in October of 1955,[6] taking a total time of about six hours. The tests were scored according to pre-established keys and protocols.

Reliabilities were estimated from the entire sample by methods indicated in Table 1, where the estimates are given, except for some that were adapted from earlier sources. Intercorrelations were computed by means of the Pearson product-moment coefficient for the most part. Frequency distributions were skewed markedly in four instances. The distribution for Hidden Figures was normalized, while those for Riddles (obvious), Water Jars, and Impossibilities were dichotomized near their medians. For these tests either biserial r's or tetrachoric r's were computed.

The Factor Analysis. Twelve factors were extracted by Thurstone's centroid method, after which the residuals were distributed leptokurtically about zero, with no absolute value greater than .09. As the first step in rotation of reference axes, an arbitrary transformation matrix was derived for orthogonal rotation of nine of the axes. Each new axis was located as near a selected test (or tests) of a previously known factor as orthogonality would permit. Further orthogonal rotations were made by Zimmerman's graphic method (24), following the criteria of simple structure, positive manifold, and psychological meaningfulness.[7]

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[5] We are indebted to Drs. Constance Lovell and Melvin J. Vincent for granting class time for the pretesting.

[6] We wish to thank Drs. L. G. Humphreys and J. W. Bowles of the Personnel Research Laboratory, Human Resources Research Center, Lackland Air Force Base, for making this testing possible, and for the cooperation of other personnel in the administration of the battery.

[7] The tables of intercorrelations, centroid factor loadings, and rotated factor loadings have been omitted from this paper and deposited with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. Order Document No. 6008. Copies may be secured by remitting $1.25 for 35 mm. microfilm or for 6 x 8 photocopies. The same tables may be found in reference (9).

Interpretation of the Factors

Of the 12 factors, eight were identified and interpreted. Of the remaining four, one was an unidentified doublet and three were residuals, none having a loading as large as .30. In the presentation following, each common factor will be mentioned in turn, with tests having loadings of .30 or higher. Where a test has loadings of .30 or higher in other factors, this information will also be given. The reference factors will be mentioned first, with comments only regarding anything unusual about the results in this analysis.

Factor A. *Verbal comprehension* (V)

31.	Verbal Comprehension	.57
5.	Circle Square II	.50
19.	Plot Titles (clever)	.46 (0 .39)
22.	Rhyming Definitions	.45 (0 .36, IF −.36)
28.	Syllables	.41
3.	Camouflaged Words	.33 (SRe .37)
4.	Chain Associations	.31 (0 .35)

It was surprising that some of the tests had such strong loadings on *verbal comprehension.* The words involved in Circle Square II and Chain Association were of such low difficulty that they should not involve much variance in this factor. Syllables does not involve meaningful words, hence its presence here calls for explanation. The explanation of these discrepancies is probably that we have here a confounding of *verbal comprehension* with the factor of *word fluency.* A marker test for the latter would probably have cleared up the picture.

Factor B. *General reasoning* (GR)

25.	Ship Destination	.64
6.	Circle Square Triangle	.49 (LE .34)
32.	Water Jars	.42 (LE .45)
18.	Planning Air Maneuvers	.39 (AX .38)
26.	Sign Changes	.33

This factor is identified principally by its marker test, Ship Destination. The other tests are rather heterogeneous as to type, but this is not unusual for tests of *general reasoning.* It was predicted that Water Jars would have a significant loading on this factor since it resembles an arithmetic-reasoning test. The other tests have had loadings of .30 and less in previous analyses on the factor of *general reasoning;* therefore, these results are not quite typical.

Factor C. *Logical evaluation* (LE)

21.	Puzzles	.55	
13.	Logical Reasoning	.50	
32.	Water Jars	.45	(GR .42)
6.	Circle Square Triangle	.34	(GR .49)
12.	Insight Problems	.33	(AX .47)

This factor has been consistently characterized by its relations to syllogistic tests, of which the marker test, Logical Reasoning, is an example. The Puzzles test offers a promising nonsyllogistic type of test for this factor. As predicted, Water Jars had a substantial loading.

Factor D. *Originality* (O)

8.	Consequences (remote)	.49	(SX .45)
30.	Unusual Uses	.46	(SX .52)
23.	Riddles (clever)	.41	
16.	Object Synthesis	.40	(SX .37)
19.	Plot Titles (clever)	.39	(V .46)
9.	Figure Analysis	.36	
22.	Rhyming Definitions	.36	(V .45, IF −.36)
4.	Chain Associations	.35	(V .31)

The presence of tests 8, 30, and 19 serves to identify this factor. With the exception of Figure Analysis, the presence of the other tests can be easily rationalized. One of the indicators of *originality* has been the giving of clever responses. Tests 23 and 22 fall in this category, for acceptable responses to these two tests must necessarily be clever. Responses to Object Synthesis would come under the category of unusual responses, and responses to Chain Associations, when scored for change of category, fit the category of "remote" associations. As usual, tests of all three kinds hang together in relation to the factor of *originality*.

Factor E. *Ideational fluency* (IF)

20.	Plot Titles (low quality)	.54	
2.	Brick Uses (fluency)	.49	(SX .45)
24.	Riddles (obvious)	.46	
22.	Rhyming Definitions	−.36	(V .45, O .36)

The first two tests provided marker variables for this factor. The score derived from the number of obvious or low-quality answers to riddles runs true to form for tests related to this factor, the number of clever answers going with *originality,* as we have just seen. The negative loading for Rhyming Definitions is an exception to positive manifold but is consistent with significant negative correlations. Perhaps it means that the too-fluent person suffers from an overabundance of potential responses that will not fit the requirements of the test.

Factor F. *Spontaneous flexibility* (SX)

1.	Brick Uses (flexibility)	.69	
15.	Object Naming	.59	
30.	Unusual Uses	.52	(O .46)
2.	Brick Uses (fluency)	.45	(IF .49)
8.	Consequences (remote)	.45	(O .49)
11.	Impossibilities	.37	
16.	Object Synthesis	.37	(O .40)

The first thing to be noted regarding this factor is that our general hypothesis 2 is supported by the fact that tests designed for *spontaneous flexibility* and for the perseveration hypothesis yield one factor, not two. In the list of seven tests, three were designed to measure *spontaneous flexibility* and two to measure perseveration.

Consider, next, which of the subhypotheses seem to be best supported. Since there is but one factor, four subhypotheses might apply to it. Two of the four tests under subhypotheses Ia—Consequences (remote) and Unusual Uses—have been found faithfully loaded on *spontaneous flexibility* in three previous analyses, two of them published (11, 23) and one unpublished.[8] They represent the subhypothesis denoting the factor as an ability to shift set freely to get away from obvious and trite responses. The other two tests listed under the same subhypothesis—Riddles (clever) and Rhyming Definitions—came out loaded on *originality* instead, perhaps for reasons suggested above. If these four tests are properly classified together, it would seem to be necessary to require or to permit more than one or two responses in order to give tests of this category some variance in *spontaneous flexibility*. All four of these tests have loadings on *originality*, Consequences (remote) and Unusual Uses leading the tests for that factor. The conclusion is that it is the *diversification* of responses which makes these two tests measure *spontaneous flexibility* also. But this is the essence of subhypothesis Ib. We doubt, therefore, that subhypothesis Ia states a necessary property of the factor.

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[8] An analysis conducted as a cooperative study with the Institute for Personality Assessment and Research, at the University of California, in Berkeley, referred to hereafter as the IPAR study.

Of the two tests listed for subhypothesis Ib—ability to respond in divergent channels—Impossibilities had a significant loading while Twenty Questions did not. Possibly the assumed diversification aspect of Twenty Questions was not as strong or as important as we had assumed. It may be that the restriction imposed by the requirement of interrelation of the questions to solve the problem destroyed the spontaneity that is necessary or did not give it sufficient play.

Both of the tests listed for subhypothesis I′a proved to be excellent and are practically pure tests of the factor. They are Brick Uses (flexibility) and Object Naming, both based upon the same principle—freedom from clustering of responses. The definition of subhypothesis I′a stresses "inertia in thinking" or a tendency to let a set run its course. This is evidently an important property of the factor *spontaneous flexibility.*

Neither of the tests for subhypothesis I′b appears in the list for the factor *spontaneous flexibility*. They are Chain Associations and Syllables, included under a subhypothesis of "elaboration of themes." Both tests had small loadings on *verbal comprehension* and Chain Associations also had a significant loading on *originality*. It can be said that there is a kind of clustering involved in these two tests, but it is a more planful affair than that involved in tests for subhypothesis I′a. If this distinction is of some consequence, it would appear that even this much active control is destructive of the spontaneity that must be permitted to emphasize the factor of *spontaneous flexibility*. Although the samples of tests under subhypotheses I′a and I′b are relatively small, the analysis clearly separated the two pairs of tests and gives what might be regarded as a somewhat decisive answer.

To summarize this discussion, we may say that subhypothesis Ib received stronger support than subhypothesis Ia, and I′a is more definitely supported than I′b. We may therefore say that *spon-*

taneous flexibility is not so much an avoidance of the trite and the obvious as it is a tendency to diversify one's responses; it is not a lack of motivation to develop a theme, but it is rather a freedom from inertia. Freedom from inertia promotes diversification of responses, hence subhypotheses Ib and I′a are quite compatible. A revised definition of *spontaneous flexibility* would read: The ability or disposition to produce a diversity of ideas, with freedom from inertia and restraints. The "unstructured situation" mentioned in the previous definition may now be regarded as merely the *occasion* for the freedom that is thus permitted.

The appearance of two of the tests in the list for *spontaneous flexibility* calls for some comment. Object Synthesis was hypothesized to measure one proposed property of persistence (subhypothesis II′b, "continued operation of habitual meanings") in spite of the fact that it had shown a significant loading on *spontaneous flexibility* in one previous analysis (11). It had had a zero loading on the same factor in another analysis in which this factor appeared (23). It does not fit the new definition of *spontaneous flexibility,* just given, very well. Brick Uses (fluency) appears in the list no doubt because of its experimental dependence with Brick Uses (flexibility), their intercorrelation being .54. One might have expected a doublet factor for these two scores, but the rotations of axes did not bring out such a factor. The consequence is that the loadings for *spontaneous flexibility* in these two variables are somewhat inflated in this analysis.

Factor G. *Adaptive flexibility* (AX)

12. Insight Problems	.47	(LE .33)
14. Match Problems II	.42	
17. Penetration of Camouflage	.40	
27. Squares	.39	
18. Planning Air Maneuvers	.38	(GR .39)
10. Hidden Figures	.35	(SRe .34)

Adaptive flexibility also definitely supports general hypothesis 2 by bringing together tests designed to measure flexibility with those designed to measure persistence in thinking, with no indication of a separate persistence factor. While four of the seven tests designed for hypothesis II are in the list above, only two of the seven designed for hypothesis II′ are in the list. The remaining tests are scattered among various nonflexibility factors, with the exception of Object Synthesis, which had a loading on *spontaneous flexibility* in this analysis. While not all of the tests designed for hypotheses II and II′ have significant loadings on *adaptive flexibility,* it can be said that no other kinds of tests appear in the list above. The tests that do appear in the list represent three of the six subhypotheses concerning *adaptive flexibility* and persistence, hence we have some rather definite answers concerning what properties do and do not belong to the factor.

In considering the subhypotheses under II, we find that both *a* and *b* are well supported, with four out of the five tests significantly related to the factor *adaptive flexibility.* Puzzles is the exception. The absence of this test is somewhat "puzzling" in view of its superficial similarity to Insight Problems. At any rate, both IIa and IIb properties stress problem solving, while most other subhypotheses do not. We may conclude that the factor *adaptive flexibility* definitely plays a role in some types of problem solving. Subhypothesis IIa pertains to restructuring or reinterpreting a problem, while IIb pertains to the production of different solutions. To what extent the different solutions depend upon restructuring or reinterpreting cannot be said. But from these results it would appear that restructuring at one or both of these stages in problem solving is a significant lead to the definition of the factor *adaptive flexibility.*

There is some support for one other subhypothesis, however, in which problem solving is not an obvious description of the task; namely, subhypothesis II′c. The definition chosen for this subhypothesis, and for the tests associated with it, is resistance to restructuring, where the use of the term "restructuring" seems to be more than a coincidence. Two of the four tests for this subhypothesis proved to be significantly related to the factor *adaptive flexibility.* Assuming that these two should help define the factor, we have added support for the restructuring property but we cannot confine it to the context of problem solving. The restructuring needed in some kinds of problems should be more properly regarded as an incidental and peculiar feature of those kinds of problems.

Let us see what the factor *adaptive flexibility* probably is not, in the light of the three subhypotheses that received no support. Note the definitions of subhypotheses IIc, II′a, and II′b—ability to drop familiar associations and adapt to new ones; tendency for continued use of learned responses; and tendency for continued operation of habitual meanings. All of these have in common the inability to desert learned habits and to adapt to new conditions by making other and perhaps conflicting responses. The unanimity of failure of the five tests associated with these subhypotheses to show relationships to the factor *adaptive flexibility* rules out the property of the interfering effects of learned associations, habits, or meanings. If there is a rigidity factor of this type, as Ferguson proposes, the five tests used in this analysis did not demonstrate it, and it can be fairly conclusively stated that it is not the same as our factor of *adaptive flexibility.* In Ferguson's work, the obtained rigidity factor was very much restricted to psychomotor tests. If his negative-transfer hypothesis applies at all, it may be confined to psychomotor habits. It does not seem to apply to thinking habits. If it does, we have not yet found the tests of thinking that would demonstrate such a factor.

We should now consider a general hypothesis regarding *adaptive flexibility* which was mentioned incidentally earlier. This is the hypothesis that there should be three parallel *adaptive flexibility* factors, depending upon the three kinds of material—figural, structural, and conceptual, in accordance with the general structure that was proposed for intellect. The tendency for factors in the structure of intellect to come in triads had not been sufficiently realized when this study was initiated to cause us to give adequate attention to testing the hypothesis of three *adaptive flexibility* factors. Furthermore, it had been noted in the results of the IPAR analysis that all three kinds of tests seemingly came out together strongly on the same factor *adaptive flexibility.*[9] There was only one representative of each type of test (figural, structural, and conceptual), however. They were: a Gottschaldt-figures test (similar to our Hidden Figures), our Match Problems test, and an Insight Problems test (of which our current test is an adaptation).

In our flexibility battery perhaps we did have enough basis for a separation of three *adaptive flexibility* factors if they exist separately and are not highly intercorrelated. We had three figural tests (Penetration of Camouflage, Hidden Figures, and Figure Analysis), three structural tests (Match Problems II, Squares, and Planning Air Maneuvers), and three conceptual tests (Insight Problems, Water Jars, and Puzzles). From the results presented above, it will be seen that all except the last two tests came out on a single factor of this kind. It should be pointed out that about half the items of Insight Problems included structural material, which might account for its behaving differently from Water Jars and Puzzles.

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[9] The study referred to in footnote 8.

The *adaptive flexibility* factor found in the present analysis, then, could be interpreted as being confined to tests of figural and structural material. Whether it is a confounding of two factors—figural adaptive flexibility and structural adaptive flexibility—or is a single, unitary factor is still to be determined. The fact that Thurstone found a factor that he interpreted as flexibility of closure, which featured tests of the Gottschaldt-figures type and a test like our Penetration of Camouflage, indicates that there might be such a factor. Thurstone did not have flexibility tests of structural content in his battery that would have made possible the testing of the hypothesis of two factors.

We seemed to have enough tests in our battery for testing the hypothesis of a separate conceptual-flexibility factor, but none was found. Two of the three conceptual tests did not go along with the other tests of the factor *adaptive flexibility* and the third, which did go along, had much structural content. There is still a possibility for a flexibility factor that is characteristic of conceptual tests only. The failure of such a factor to appear might be explained by the fact that the Water Jars test, one of the three, represents a subhypothesis (persistence of a maladaptive habit) none of whose tests was related to the factor *adaptive flexibility*.

The question of three separate *adaptive flexibility* factors is still an open one. If it should turn out that the obtained factor is an underlying temperamental or motivational trait, one such trait could account for flexibility or lack of it in dealing with all kinds of material. If there were only one such factor, it would be difficult to account for the absence of Puzzles and Water Jars from the present adaptive-flexibility-factor list.

Considering the findings with regard to the factor *adaptive flexibility* along with what we know about the structure of intellect, we could tolerate a radically different hypothesis. This is the idea that *adaptive flexibility* is an originality dimension that pertains to figural and structural material. Tests of the known factor of *originality* have been almost exclusively in the conceptual category. This leaves room for one or two originality factors in the figural and structural categories. The kind of mental operation required by tests of *adaptive flexibility* could be described as the production of ideas that are either unusual, clever, or remotely connected. The problems involved require insights and steps that are out of the ordinary; they require ingenuity.

An investigation of this hypothesis would not be difficult. It would be a matter of setting up tests composed of figural and structural material analogous to the tests of the presently known *originality* factor, to see whether they go with the factor *adaptive flexibility*. If the proposed conjecture proves to be correct, we might have to consider renaming the present factor of *originality*, calling it "conceptual adaptive flexibility."

If *originality* is, indeed, a conceptual form of *adaptive flexibility*, we should have expected Insight Problems to have at least some *originality* variance since about half of its items may be regarded as involving conceptual material. In order to make a check on this point, we subdivided the items in this test into two groups judged to be structural and conceptual by inspection. There were six items in the structural part and four items in the conceptual part. Papers were rescored, providing two scores. The two scores were correlated separately with two of the best *originality* tests in the battery—Riddles (clever) and Consequences (remote)—and two of the best *adaptive flexibility* tests—Squares and Match Problems II. From the hypothesis we should predict that the structural score from Insight Problems should correlate higher with the *adaptive flexibility* tests and the conceptual score should correlate higher with the *originality* tests. Comparisons were made after correcting the coefficients for unreliability of the Insight Problems scores. The general trend was in the direction of that called for by the hypothesis, but the results were far from decisive.

This investigation has brought out the need for a revision of the definition of the factor known until now as *adaptive flexibility*. In spite of the fact that we have more detailed evidence as to its properties, we are left with some uncertainties. We found reason to drop the term "problem" in the definition. Probably we are justified in saying more than that it is an "ability to change set." We now see that a certain kind of persistence in thinking represents qualities opposite to flexibility, i.e., persistence that prevents restructuring. Restructuring seems to be an aspect of every subhypothesis that was supported by the results. Restructuring of both interpretations and of productions could be involved. In view of the possible interpretation of *adaptive flexibility* as an originality dimension, we should ask whether restructuring is a property of tests of the factor of *originality*. Examination of the list under that factor shows that this idea is not unreasonable. At any rate, whatever the definition of the factor *adaptive flexibility* may eventually be, the concept of restructuring would seem to be a significant aspect of it.

Factor H. *Structural Redefinition* (SRe)

3. Camouflaged Words	.37	(V .33)
10. Hidden Figures	.34	(AX .35)

In both of these tests the examinee must isolate parts of a larger organization and produce new subwholes by the reorganization of elements. In Camouflaged Words, the elements are letters. Given embedded in a meaningful sentence, a certain combination of contiguous letters must be isolated (ignoring the surrounding letters and punctuation material) to produce a new word structure bearing no conceptual relationship to the original information. In Hidden Figures, some of the lines composing a complete figure must be isolated from the surrounding design to produce a new organization as required by the instructions. In both tests the examinee is told what kind of new organization is to be produced—a word naming a sport or a game in the one case and one of five given figures in the second case. Although it is not usually wise to name a new factor and to interpret it when it is based upon only two tests, the common feature is so clear in this case that we propose the title of *structural redefinition*. We have general, logical support for doing so because the factor seems parallel to a known factor called *redefinition,* which has been found only in conceptual tests. By analogy to the definition of that factor, we suggest for this one the following: An ability to change the function or significance of structural elements of an object to use them in a new way.

In most tests in which structural factors have been found thus far, the material has been in the form of letters, words, or numbers. From the fact that such tests as Hidden Figures and Match Problems help define factors that we recognize as structural, we obtain a little broader conception of what the structural-thinking category means. It seems to pertain to perceived *arrangements* of elements, and lines are among such elements. In this connection it seems significant that the Hidden Figures test appears with a letter-and-word test while the Penetration of Camouflage test (hidden faces) does not. Faces are more than arrangements of similar elements. They possess figural properties of shape, size, texture, and so on. The appearance of Penetration of Camouflage on the factor *adaptive flexibility* suggested the possibility that the obtained factor *adaptive flexibility* represents a confounding of figural and structural factors of flexibility. We might have to accept the same possible confounding of figural and structural redefinition in connection with factor *structural redefinition* except for the fact that the hidden-faces test does not appear on it.

Factor I. *Unidentified* (Un)

7. Consequences (low quality)	.58
29. Twenty Questions	.32

This factor remains unidentified, although considerable speculation has resulted in the tentative hypothesis that it may represent certain elements of planning, and possibly *conceptual foresight.* It is probable that these two tests appear together on this doublet due to the fact that Consequences (low quality) has only one significant correlation with any test in the battery; an r of .31 with Twenty Questions. The latter test is of such a nature that considerable planning and foresight are required in framing the questions. Each question written has an effect on subsequent questions, bearing in mind that a hypothetical "yes" or "no" answer must be considered to each question.

Discussion

This general discussion will consider briefly the relations of the findings to the hypotheses with which the study was started, some implications for the structure of intellect, and some implications for concepts of rigidity.

The Hypotheses Supported. One of the general hypotheses was to the effect that we should find *spontaneous flexibility* at the pole opposite to a quality of perseveration of thinking, and *adaptive* *flexibility* at the pole opposite to a quality of persistence in direction of thinking. With a liberal number of tests of all four qualities represented in the analysis, the results fully supported our expectations on this general point.

More specific subhypotheses had to do with the properties of the factors. Since only two factors were found in this area, we may list the alternative subhypotheses for each of the two together. Alternative ideas concerning the nature of *spontaneous flexibility* were: (a) ability to shift set to get away from obvious and trite responses, (b) ability to think in divergent channels or directions, (c) freedom from inertia of thinking, and (d) tendency toward elaboration of themes rather than change of theme. Of these four subhypotheses, (d) received no support at all, and (a) only very weakly. We are therefore strongly inclined toward the conception that *spontaneous flexibility* is a freedom to think in varied directions. Spontaneity still seems to be an important aspect of performance on tests of the factor. Further work should be done on this point, however.

Alternative ideas concerning the properties of *adaptive flexibility* were: (a) ability to restructure problems, (b) ability to solve problems in different ways, (c) ability to desert learned associative connections and to adapt to new ones, (d) freedom from continued (maladaptive) use of learned procedures, (e) freedom from continued operation of habitual meanings, and (f) lack of resistance to restructuring. Of these six subhypotheses, (a), (b), and (f) are supported by the results while the others are not. We can say that *adaptive flexibility* is not an ability to resist the effects of negative transfer of learning, whether the learning is in the form of procedures, associations, or meanings. Thus, it seems that Ferguson's hypothesis does not apply to rigidity of thinking. Of the three hypotheses supported, two have to do with problem solving but one does not. This permits us to accept a broader conception of the factor; it seems not to be confined to problem solving.

An incidental hypothesis tested was that a Water Jar test of the Luchins type measures the factors of *general reasoning* and *logical evaluation* more probably than it does rigidity of thinking. The results fully supported this expectation. Although our form of the test is not identical with that of Luchins, our findings with regard to this test probably apply to the Luchins form also since Leavitt (16) has concluded, after examination of numerous studies, that many variations of the Luchins test seems to behave similarly. An experimental study of our form of the test indicates that if the first five items establish a procedural set at all, it is very ineffective in determining behavior on the later items (4).

The Structure of Intellect. The proposed structure of intellect (6, 7) would call for three spontaneous-flexibility factors and three adaptive-flexibility factors. No study, including this one, has provided an adequate test of the hypothesis of three flexibility factors of the spontaneous type. This problem is still to be investigated. No previous study gave any possible test of the three-factor hypothesis regarding flexibility of the adaptive type. The prior IPAR study gave results that seem to be against the hypothesis since one test of each type—figural, structural, and conceptual—had a strong loading for a factor identified as *adaptive flexibility.* This suggests that if there are three factors they are substantially correlated. In the present investigation we seemed to have ample conditions for a separation of three factors. One factor was found. Two of the three conceptual tests had no significant loadings on it. The third did, but at least half of its items could be regarded as structural in type. The obtained *adaptive flexibility* factor, then, could be either a single factor that cuts across figural and structural boundaries, or a confounding of two correlated factors, one figural and one structural.

An entirely new hypothesis was proposed regarding *adaptive flexibility;* a hypothesis that has a definite implication for the structure of intellect in the divergent-thinking area. This is to the effect that the obtained *adaptive flexibility* factor is one of originality dealing with figural and structural material, parallel to the known *originality* factor, which is in the conceptual column. If this hypothesis is accepted, after further investigation, we would lose one row of the divergent-thinking matrix of factors but we would have completed another. We should then have to consider whether to call the present *adaptive flexibility* factor "figural-structural originality."

The new factor that was tentatively named and interpreted as *structural redefinition* fits nicely into a vacant cell of the convergent-thinking matrix of factors in the structure of intellect. If the interpretation is correct, this would complete a row of factors in that matrix. The companion factors are *visualization,* in the figural column, and a factor that we shall now have to call "conceptual redefinition" in the conceptual column. The latter is measured by such tests as Gestalt Transformation, in which an object or part of an object must be used in some new and totally different way from its common use or function.

As pointed out above, the new emphasis in the definition of *adaptive flexibility* is in the concept of restructuring. Restructuring and redefinition are similar concepts, calling for some logical distinction. One distinction is that the redefinition type of factor is placed in the general category of convergent-thinking factors, whereas the restructuring type of factor is placed in the general category of divergent-thinking factors. Convergent thinking is defined as focusing the direction of thinking toward one right answer. This has been true thus far of tests of redefinition and visualization. Divergent thinking is defined as the dispersal of thinking in different directions, and often more than one right answer is called for. Probably a better distinction between redefinition and restructuring is that the former involves changes of meaning, significance, or use, whereas the latter involves changes of direction of thinking. For lack of more definitive information, we shall have to leave the distinction somewhat indecisive.

Other Concepts of Rigidity. In mentioning some of the concepts related to rigidity early in this paper, those of gestaltbindung and functional fixedness were included. Can we throw any light on the possible meaning of these concepts from the results reported above? We have found perseveration and persistence of direction in thinking to be essentially opposite to the two thinking-flexibility factors. We have only indirect evidence concerning the other concepts.

The term "gestaltbindung" seems to come nearest to what we referred to as resistance to restructuring. Thurstone used the term in this way in interpreting his factor of flexibility of closure, which he found in perceptual tests, including tests involving hidden figures and hidden faces. In our analysis these tests came out with the others on *adaptive flexibility*. Through these lines of evidence we can suggest the hypothesis that gestaltbindung, like persistence, is a quality opposite to *adaptive flexibility.*

The term "functional fixedness" has been used in connection with problem solving to denote the hesitation shown by subjects to adapt a familiar object to some new and unusual purpose. The factors, and there are two, that seem to come closest to this concept are the two redefinition factors, one dealing with meaningful objects and the other with structural elements such as lines and letters, which are organized into units. Where there is functional fixedness, the familiar meaning, significance, or use of an object remains the same even when the solution of a problem or the attainment of some other goal, as in a test, requires a radical change in the meaning of the object or part of an object. This is precisely the kind of task in our test called Gestalt Transformation, a faithful representative of the factor of *conceptual redefinition.*

Summary

This study was designed to clarify the nature of two types of thinking flexibility that had been found in three previous investigations of the Aptitudes Project and to examine their possible relations to the concept of rigidity and its affiliated concepts. We had some incidental interest in the factorial nature of the Luchins Water Jar test and its possible relations to our factors of flexibility.

Hypotheses were set up as a basis for selecting and constructing tests for the battery to be analyzed. In this step we hypothesized that one form of rigidity—perseveration—is a quality opposite to *spontaneous flexibility* and another form of rigidity—persistence—is a quality opposite to *adaptive flexibility.* From two to three subhypotheses were generated as to the more precise nature of each of these four concepts. From one to four tests were selected or constructed to test the applicability of each subhypothesis.

A battery of 28 experimental and reference tests, which yielded 32 score variables, was administered to 208 Air Force Cadets. Twelve factors were extracted from the correlation matrix and the axes were rotated orthogonally.

Five reference factors were identified: *verbal comprehension, general reasoning, logical evaluation, originality,* and *ideational fluency.* A few of the new tests have some promise as measures of some of these factors. One new factor emerged, identified as *structural redefinition,* by analogy to the known *redefinition* factor, which deals with conceptual material. Other factors included an unidentified doublet, three residuals, and the flexibility factors, which were the center of interest.

The two usual flexibility factors were identified—*spontaneous*

flexibility and *adaptive flexibility*—but no additional factors recognizable as perseveration, persistence, or rigidity. Some tests designed to measure perseveration had significant loadings on *spontaneous flexibility* and some tests of persistence had significant loadings on *adaptive flexibility,* to support the general hypothesis. From the results, the revised conception of *spontaneous flexibility* is that it represents an ability or disposition of freedom from inertia in thinking, making possible the production of a diversity of ideas. The new conception of *adaptive flexibility* emphasizes restructuring of interpretations and approaches, in problem solving and elsewhere.

The adaptation of Luchins' Water Jar Test was found to have almost no relationship to either flexibility factor. Its strongest factorial components were found to be *logical evaluation* and *genera. reasoning,* to about equal degrees.

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